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FOOD DEHYDRATION'S EVOLUTION TO A PROMISING PEACE TIME INDUSTRY

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Food dehydration has gone through many cycles of feast and famine. Prosperous times for this industry have been during wars. Peace-time uses of dehydrated foods declined sharply. After World War II, however, the food dehydration industry underwent a change. No longer considered a "war baby", it has grown into a full-time processing industry and now stands shoulder-to-shoulder with other food preservation methods.

Let's examine developments making this change possible. Then we shall look at foods being dried and briefly discuss drying methods. The future of the industry will be predicted.

Drying of foods is an ancient art. Used by prehistoric people, it extended consumption of food from seasons of abundance to months of shortage. Dates, figs, apricots and raisins were dried by early inhabitants of the Near East. They are dried in much the same ways today in that same area for the same reason. Other foods are dried for convenience or lower-costs in handling.

American Indians, too, dried many foods including meat and corn. "Chuño", prepared from native potatoes in the Andes highlands, was a dried food of 2 to 3 thousand years ago. During the Crimean war our British friends dried potatoes, carrots, and other vegetables and shipped them to their overseas troops. In our own Civil War, Union troops ate dried sausage containing peas and meat. For the Klondike gold rush, dried potatoes were imported from Germany. In early California, onions and fruits were dehydrated. During World War I, both the British and French armies consumed sizeable quantities of dehydrated vegetables and meats.

During the late 1930's and early 1940's many research techniques, later to stimulate the dehydration industry, were initiated. At this time, drum-drying was applied to whey, buttermilk, soup mixtures, and tomato products. Spray-drying was used for several dairy products and eggs. A few fruits were vacuum-dried, some were dried in trays, but many were still being sun-dried. Dehydrated onions were fairly well established.

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It was during World War II, however, that dried foods became potent as a modern weapon. They were used not only by troops, but also by our civilian allies. Dried milk, eggs, and potatoes are well remembered by overseas soldiers. In this period, there was a vast expansion of drying plant capacity. At one time there were 139 vegetable dehydration plants in the United States. Maximum annual rate of production was 132 million pounds of dehydrated potatoes and 76 million pounds of other vegetables. On the other side of the conflict, Germany, too, had a large drying industry which produced 66 million pounds of dried potatoes in 1944. 1/

Egg dehydration remained active for several years after World War II, but volumes dropped sharply after the Korean conflict. Skim milk production, in contrast, expanded steadily throughout the whole post-war period. Dried onions and potatoes maintained a small volume, and gradually there developed the industry we know today. Potato processing plants are now in all of the important fall crop growing areas. Potato flakes, a development of the Department of Agriculture, provided the spark that helped accelerate this growth. Supermarket shelves presently stock a dozen different dried potato products.

During the last few years, meat has become important as a peacetime dehydrated food. Some is spray-dried; some freeze-dried. The U. S. freeze-drying industry started in 1959 and by 1963 had a volume of about 11 million pounds. Much of its volume, perhaps as much as 20 percent, is contracted by the Quartermaster Corps. The civilian market is expanding, however, and fruits and vegetables are assuming increasing importance as freeze-dried items.

During and immediately following World War II, many persons in government and industry were concerned at severe cutbacks expected in drying. USDA and the War Food Administration actively promoted a peacetime dehydration industry. Much research in food dehydration was initiated by private industry and the Department's Utilization Laboratories. The Quartermaster Corps of the Armed Forces was particularly important in research and fostering growth of our present drying industry. Probably drying, as it exists today, is largely a result of farsighted efforts and decisions made two decades ago.

Present Status of the Drying Industry -- Currently, skim milk is our largest volume dried food. Whey is another dairy product dried in large quantities. Dehydrated eggs are important, as are sausage and other pork products. Citrus pulp, raisins, and prunes are substantial fruit items. Potatoes and onions are the major vegetables.

Now I'd like to describe some drying methods in common use. The method selected is determined by raw material characteristics, quality requirements and economic factors. Sun-drying, the oldest method of drying, is still used for most of the

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1/ Van Arsdel, Wallace and Copley, Michael J., Food Dehydration, Vol. 1 The Avi Publishing Co., Westport, Conn., 1963, 185 pages. Also see Von Loesecke Harry W., Drying and Dehydration of Foods. Reinhold Publishing Corp., New York 2nd ed., 1955, 300 pages. Both books devote many pages to history and development of the drying industry

raisin crop. Because in some years unseasonal rains damage large quantities of the raisin crop, the Western Regional Research Laboratory of USDA has developed an artificial method for raisins and this may alter their drying. Other important sun-dried fruits include currants, peaches, apricots, and pears.

Another commonly used method of fruit drying is one where artificial heat is applied, under atmospheric pressure. Hot air dryers are used for prunes, apples, some raisins, and many other foods. Food is placed on trays or belts that move through the drying chamber. Heated air passes over or through the food and carries away the moisture.

Another type hot air dryer is the kiln-dryer. It is a batch type drier commonly used for hops and apple slices in which hot air passes up through the product. In belt-trough drying heated air passes through the product while gently moving through the unit on a continuous basis. The rotary dryer is another continuous type in which the product passes through a slowly heated cylinder.

The most common method of drying liquids and purees is spray-drying. With this method the product is sprayed into a heated chanber and the particles lose their moisture as they drop through the heated air. A rotary drum-dryer may consist of either one drum or two, and the end dried product is a thin film. Two products dried in this way are white potato flakes and sweetpotato flakes. Both of these flake products, by the way, are USDA developed. The new dried prune flakes, packaged with bran flakes, also are drum-dried.

Vacuum-drying may be done by batch or continuously. A continuous vacuum belt-dryer is used in the USDA Utilization Laboratory in Philadelphia for extensive research on whole milk powder. Other continuous vacuum dryers are used commercially for citrus juice, coffee, and tea.

Freeze-drying is a unique vacuum-drying method in which food is frozen prior to drying and kept frozen during the dehydration. Foods dried in this manner are of high quality but are relatively high in cost.

Explosive puff-drying is an interesting drying method. Rice and wheat for breakfast cereals have long been treated in this manner. Now vegetables and berries are puffed. Food is partially dried by usual ways and then loaded into a cylinder. Pressure is raised through application of heat. One end of the cylinder is then opened, and the sudden change of pressure allows the food to increase in size. It is then more easily dried to satisfactory levels of about 2% moisture. 2/

Another new fledged drying method is foam-mat drying. Here, an emulsifier is mixed with the food. Then the foam is laid out on a tray or belt, and the foam is dried to an extremely low moisture content as hot air is blown up through it. Much of the developmental work of this technique has been done by researchers of the Utilization laboratories of the Department. Other new drying

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2/ Van Arsdel, W. B. and Copley, M. J. Food Dehydration, Vol II, The Avi Publishing Company, Westport, Conn., 1964, 721 pages. This book is devoted to a detailed description of products and technology.

methods are now being examined and developed. As indicated, quality of product, raw material characteristics, cost of utilities, and many other factors determin which method is most useful for a given product.

For most of the drying methods described above there is little information available on costs of drying. In the Marketing Economics Division of ERS we are currently conducting a study with this in mind. Results are not yet available. Costs of drying vary depending on the method used, product being dried, moisture content of the food, quality of dried food desired as a dried product, cost of utilities, scale of operation, and many other factors. Generally sun-drying methods are considered as the cheapest. Probably most fruits dried in this manner are dried for less than $\frac{1}{2}$ cent per pound of water removed.

Spray-drying and drum-drying are among the lowest cost artificial heat drying methods although tray and belt-drying are also relatively inexpensive. These are generally less than 1 cent per pound of water evacuated. Explosive puff-drying, rotary-drying, and several of the other artificial heat methods are slightly higher, but still maintain relatively low cost levels. Foam-mat drying may have costs of about 2 to 3 cents per pound. Vacuum-drying is acknowledged as being an expensive drying method, and costs are in the range of 3 to 4 cents per pound. Freeze-drying costs are ven more -- probably 7 to 25 cents per pound of water extracted. 3/ These cost figures cited are rough rule of thumb approximations and are given to show the general levels of costs.

Future of the Dehydration Industry - One factor that has kept drying of foods from developing at a faster rate has been lack of quality in the finished product. This has been evidenced in poor flavor and texture, shriveled appearance, loss of nutrients, and poor rehydratability. In addition, packages have been poor, and many of the fruits have had a sulfur taste and odor. Other dried foods particularly the meats, have had poor keeping qualities.

During the last two decades, however, newer drying methods including vacuum, foam-mat, and freeze-drying have raised quality levels. In addition, many of the older dehydration techniques have undergone extensive changes that result in higher qualities. New heat application methods may lower drying times to improve quality. Because of economies of scale operating in the drying industry, as well as in other areas of food processing, costs are expected to be relatively lower. Newer packages, uniquely designed for specific dried products are now on drawing boards and will be available. Higher qualities of dried foods, new and better processing techniques tailored for individual foods, lower costs, more quality control and better package design -- add up to a much larger drying industry than exists today. All these point to a better, more versatile drying industry with added application in our peacetime economy.

3/ See Bird, Kermit. Freeze-Drying of Foods: Cost Projections, MRR-639, January 1964, ERS, USDA, for details on freeze-dry processing costs.

Grocery shelves of today are stocked with many more dehydrated products than there were five years ago. In the future more and improved dehydrated foods will be available. This is not only at the consumer level, but in food service as well. Dehydrated food products of the future will offer convenience, storability, and utility that may not be obtained from other processed foods.

Table 1: U. S. production of dehydrated milk products, 1948 - 1963

Year	Whole Milk	Skim used for human consumption	Skim used for animal consumption	Buttermilk
		-million pounds-		
1948	170.1	681.5	13.1	41.8
1949	125.5	934.9	21.2	49.4
1950	125.0	881.5	17.4	48.8
1951	131.0	702.5	14.3	45.5
1952	102.3	863.2	25.3	47.1
1953	101.2	1213.8	21.0	57.4
1954	92.7	1334.0	20.4	56.3
1955	108.3	1365.8	20.1	58.3
1956	110.3	1489.9	19.3	64.3
1957	103.2	1623.9	21.2	70.4
1958	87.7	1709.7	21.2	77.2
1959	90.4	1723.2	23.3	81.5
1960	98.0	1818.6	25.9	86.4
1961	81.7	2013.3	27.7	89.0
1962	79.1	2225.8	30.3	86.4
1963 1/	78.7	2130.8	28.0	87.3

1/ Preliminary data.
Source: Agricultural Statistics for 1962 and 1963. Also SRS, USDA.

Table 2: U. S. Production of dehydrated dairy products, 1948 - 62

Years	Cream	Whey	Casein	Malted milk powder	Ice Cream Mix
				-million pounds-	
1948	.3	125.2	14.4	13.4	N.A.
1949	.2	159.4	18.3	25.4	N.A.
1950	.5	155.6	18.5	30.7	N.A.
1951	1.0	139.9	21.6	33.4	N.A.
1952	.9	164.1	7.5	29.8	N.A.
1953	.7	185.0	5.5	32.5	N.A.
1954	.8	189.6	3.1	31.4	N.A.
1955	.8	211.0	2.5	33.5	4.0
1956	.8	212.0	1/	31.2	4.0
1957	.5	234.4	1/	34.6	4.0
1958	.6	233.3	1/	32.8	4.0
1959	1/	247.3	1/	26.6	4.0
1960	1/	276.9	1/	24.5	2.0
1961	.2	265.0	1/	24.0	2.0
1962	.7	283.6	1/	23.1	2.0

1/ Information not released since less than 3 firms reporting.
Source: Agricultural Statistics for 1962 and 1963, September 1963 issue of Canner-Packer, and SRS, USDA.

Table 3: U. S. production of dehydrated eggs, 1941 -1963

Year	Whole Eggs	Albumen	Yolk	Total
		-million pounds-		
1941	31.2	4.4	9.6	45.3
1942	226.1	2.3	7.3	235.6
1943	252.9	2.1	7.0	262.0
1944	311.4	2.3	7.1	320.7
1945	97.0	1.7	7.2	105.9
1946	115.3	2.1	8.0	125.4
1947	80.0	1.5	4.0	85.6
1948	36.0	2.7	5.6	44.3
1949	69.4	2.3	4.3	76.0
1950	87.0	3.6	2.8	93.4
1951	10.5	3.8	3.3	17.6
1952	2.7	6.6	8.1	17.3
1953	5.3	5.9	8.3	19.5
1954	2.9	9.3	10.3	22.5
1955	3.2	10.6	9.3	23.1
1956	4.9	8.8	8.4	22.1
1957	10.0	9.6	9.1	28.6
1958	8.4	9.0	8.0	25.3
1959	31.8	11.0	11.9	54.7
1960	27.6	8.0	10.5	46.1
1961	32.4	9.6	11.7	53.8
1962	26.7	10.0	14.0	50.7
1963	23.4	8.7	12.7	44.7

Source: Agricultural Statistics for 1962 and SRS, USDA.

Table 4: U. S. inspections of meat: smoked, dried or semi-dried, 1952-63 1/

Years	Beef 2/ smoked and/or dried	Pork 2/ smoked and/or dried	Bouillon cubes	Sausage to 3/ be dried or semi-dried	Dried beef slices	Fish
			-million pounds-			
1952	51.2	2547.4	---	119.4	5.2	n.a.
1953	51.6	2227.4	---	124.3	4.8	n.a.
1954	58.4	2233.8	2.8	130.4	5.2	n.a.
1955	60.8	2579.7	1.9	135.9	4.9	n.a.
1956	59.8	2619.5	1.9	143.2	4.2	n.a.
1957	55.4	2416.2	2.2	140.1	4.2	.08
1958	49.3	2319.6	1.7	140.1	4.1	.09
1959	52.0	2639.5	3.9	129.8	2.9	.09
1960	53.6	2568.7	2.7	140.8	3.3	.09
1961	48.4	2492.9	3.2	132.0	3.2	.08
1962	55.0	2512.3	2.2	132.7	2.9	n.a.
1963	53.5	2565.2	n.a.	148.7	n.a.	n.a.

1/ Federally inspected meats only. Not production since some meat inspected more than one time.
2/ Does not include meat placed in cure, cooked meat, loafmeat, nor canned meat.
3/ Does not include fresh finished, franks, wieners, smoked or cooked sausages.
Source: Agricultural Statistics 1962 and 1963. Also Livestock, Meat, and Wool Market News, AMS, USDA.

Table 5: U. S. production of dried fruits 1941-63

Years	Dates	Figs	Prunes	Raisins	Apples	Apricots	Peaches	Pears	Citrus pulp and meal
					-thousand tons-				
1941	5.8	33.5	184.6	209.0	18.5	19.7	14.8	3.7	32.7
1942	7.7	28.2	165.3	254.0	22.1	20.8	23.2	2.7	29.7
1943	10.8	36.7	192.4	401.0	20.1	6.6	16.4	4.2	47.4
1944	13.2	35.2	146.9	309.5	21.0	25.8	26.7	4.0	67.1
1945	6.8	32.6	207.0	241.0	14.1	7.8	22.8	5.4	68.7
1946	16.7	36.6	191.8	193.0	17.1	18.0	25.0	4.6	108.5
1947	10.2	38.0	174.4	306.0	14.8	15.3	17.1	2.6	96.2
1948	16.2	30.3	147.6	231.5	7.7	12.4	8.1	1.0	154.2
1949	14.1	28.4	124.7	259.0	14.0	14.2	14.3	2.2	134.3
1950	15.1	24.4	119.8	156.0	19.0	14.2	7.3	1.3	163.4
1951	18.8	29.5	149.4	242.0	10.5	7.6	9.2	1.6	187.5
1952	16.5	28.1	102.2	288.0	10.6	8.2	7.6	1.5	218.1
1953	17.0	24.3	111.7	233.0	9.9	16.0	8.6	1.1	223.3
1954	15.4	25.6	139.8	168.0	11.1	6.6	9.8	3.0	287.8
1955	25.3	25.4	95.9	225.0	11.7	14.4	7.0	2.3	262.5
1956	19.2	24.8	151.0	209.0	10.8	9.1	7.4	1.8	297.3
1957	23.3	22.7	127.2	163.0	13.5	7.7	7.8	1.9	296.6
1958	19.6	23.2	63.7	186.0	12.3	2.9	5.1	1.1	291.5
1959	26.0	19.1	104.5	223.0	11.4	8.2	8.6	1.8	320.6
1960	22.1	17.2	98.7	194.0	8.6	9.7	5.5	1.6	284.2
1961	21.4	18.5	101.5	228.0	11.6	5.9	4.4	1.6	320.5
1962	22.6	20.2	109.7	191.3	12.9	5.2	6.3	2.0	419.7
1963 1/	22.6	18.5	88.4	251.8	n.a.	8.7	5.9	.8	311.1

1/ Preliminary data.

Source: Agricultural Statistics for 1962 and 1963. Citrus pulp figures from unpublished AMS data, USDA.

Table 6: U. S. production of dehydrated vegetables 1/ 1949-63

Year	Potatoes, white
	-million pounds-
1949	4.4
1950	23.1
1951	19.6
1952	9.2
1953	25.5
1954	22.5
1955	35.2
1956	40.3
1957	47.2
1958	74.0
1959	95.7
1960	126.3
1961	106.5
1962	116.0
1963 2/	122.0

1/ Complete volume information unavailable for other vegetables. An estimate for 1959 listed onions at 20 million pounds, garlic and peppers at 10 million pounds each, and "other vegetables" at 20 million pounds.
2/ Preliminary data.
Source: SRS, USDA, and National Potato Council.